ARM Vision 2000

As seen by the

ARM Cloud Properties Working Group

July 2000

Major Contributors: Gerald Mace, Roger Marchand, Mark Miller and participants of the ARM Cloud Working Group meeting in Salt Lake City, December 1999**.**

1. Introduction

The stated goal of the ARM program is to improve the representation of clouds and radiation in climate models. The ARM program will ultimately be judged a success or failure based on its contribution in this area. ARM has taken the initial necessary steps toward meeting these objectives by establishing and maintaining a mature and accessible data stream over the last several years. It is now evident that while challenges remain, the initial "bricks and mortar" phase of the program has been passed. In order to progress toward the overarching goal of improving climate models, the ARM program must, 1) maintain the existing data streams for some period of time and 2) facilitate a use of the ARM dataset that will ultimately lead toward new and (hopefully) improved cloud and radiation parameterizations. In this document we address aspects of the second programmatic objective, namely how ARM can facilitate use of its data so that the overarching goal of ARM is realized. In this document, we do not address the first programmatic objective. We do recognize, however, that a) maintenance of a continuous and research-quality data stream is absolutely critical for at least the 3-5 year timeframe and that, b) the cost of meeting this fundamental commitment impacts significantly what the program infrastructure can be expected to accomplish in other areas. This second point assumes flat or shrinking budgets in the coming years.

From the perspective of the Cloud Properties Working Group, we discuss how ARM, through, careful planning and direction of available resources can facilitate use of the ARM data in such a way as to ultimately improve cloud and radiation parameterizations in climate models. Of course discussion of how to foster use of the ARM data has been addressed continuously during the initial years of the ARM program. It was recognized early that, given our then state of knowledge, the problems that must be addressed initially separated quite naturally into subdisciplines. Working groups were established that concentrated on the subdisciplines of Single Column Modeling (SCM), Instantaneous Radiative Flux (IRF), Aerosols and Clouds. The individual sets of problems faced by these groups were such that very little interaction between the groups was necessary for progress to be made in each area. Therefore, very little facility was established for these working groups to interact and they tended to evolve somewhat separately. While all the group-specific problems have not been solved, significant accomplishments have been made and our general knowledge has advanced such that substantial interaction between the sub-disciplines is now necessary. Even though the subdiscipline-specific problems must still be given meaningful support, substantial interdisciplinary interaction between the groups is now needed to drive the program toward its goals. For this interaction to occur efficiently, the working groups must evolve from what has been effective in the past.

While the loosely organized working group-centric model has fostered substantial progress, one of the less desired outcomes of this model is the tendency of a group or individuals within a group to work on a set of problems with ARM funding that may not be beneficial for the larger program. In fact, In some cases, the working groups have fractured in such a way as to become ineffective. In many cases, the scope of the problems being worked on by a group have become such that one component of a working group seldom communicates with another component. In order to achieve the level of inter and intra-group interaction that is now necessary, the working groups must be structured so that the larger science questions ultimately determine the goals of each group (and subgroups therein) and dictate how an individual working group moves toward achieving these goals. This management structure ultimately must be driven from the top by careful articulation of a set of science questions that ARM has committed to addressing.

Following the basic structure of the ARM science team described by the Chief Scientist at the 2000 science team meeting, we assume that the science team executive committee (STEC) will be formed by the nominal heads of the working groups and others within the ARM infrastructure. We further assume that the STEC will have the primary responsibility of providing research focus to the working groups through synthesis of the large issue science questions. Based on the needs articulated to the working groups from the STEC, each group will formulate a set of focused science questions that will be addressed by smaller teams of interested individuals. The information should then flow both to and from the working groups through interaction with the ARM program infrastructure and science team at large.

We provide now an interpretation of this strategy in terms of the past and future activities of the Cloud Properties Working Group.

2. The Cloud Properties Working Group

The progenitor of the Cloud Properties Working Group (CPWG) was the Cloud Working Group (CWG). The CWG through the hard work of its members accomplished much during its lifetime. These accomplishments included defining what products were necessary to characterize the hydrometeor distribution in the vertical column, identifying a set of instruments needed to derive those distributions, and overseeing the installation and operation of those instruments. The CWG is also credited with developing and implementing the initial set of data integration codes so that value-added information is provided to the science team and archived. Like the other working groups, the CWG defined a set of problems that were quite specific to its own somewhat narrow science focus. A large subset of these problems concentrated on developing new and validating new and existing cloud property retrieval algorithms designed for inverting the raw data streams into cloud properties. While this initial set of problems is not yet solved, substantial enough progress has been made to begin contemplating the direction this effort should take in the near future.

In order to address effectively the large-issue questions important to the ARM program, the organizational structure of the new CPWG should foster substantial interaction with the other working groups while maintaining focus on the remaining CWG-specific problems. This requires a shift in emphasis from that of the predecessor CWG. Most of our efforts in the last 3-5 years have been concentrated, for the most part, in algorithm development focus areas. While we understood that in the future we would need to provide an integrated cloud properties product to some set of users, the algorithm development focus areas dictated, to a large degree, what research was conducted. As discussed above, little thought was devoted to that step in the process that will ultimately bear the most fruit for ARM; namely in the interaction of the CPWG with the modeling and radiation transfer working groups. Along the lines of our discussion in the previous section, we propose a fundamental shift in our approach to the conduct of the CPWG from that of the CWG. We begin with the product that will form the basis of our programmatic interaction with the other working groups.

Table 1: Proposed CPWG Integrated Product – CRM/SCM Interaction

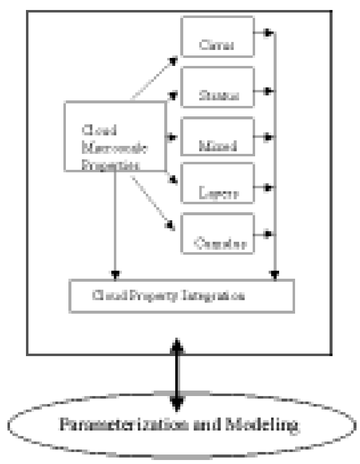
- Generate a 60 minute temporal, 250 meter vertical operational product that includes the following items:

1. **Cloud Location** (Subsample ARSCL)
2. **Cloud Fraction** (Best Estimate - Combine ARSCL, WSI, etc.)
3. **Cloud Type** (Best Estimate - Combine sounding, mwr, lidar depolarization, etc)
    a. convective, stratiform
    b. ice, mixed phase, water
    c. precipitating, non precipitating
4. **Layer-mean Bulk microphysics** (climatological or retrieval algorithms)
    a. Liquid-phase non-precipitating overcast stratiform
    b. Cirrus
    c. Mixed phase
    d. Multi-Layer
    e. Convective
5. **Radiative Properties – Interaction with IRF**
6. **Vertically Resolved microphysics** (climatological or retrieval algorithms)
    a. Liquid-phase NonPrecip
    b. Liquid-phase precipitating stratiform
    c. Convective
    d. Mixed Phase
    e. Cirrus
7. **Radiative effects**
    a. Flux Profile (Calculations –IRF interaction)
    b. Surface effect (Observations)

Table 1 describes an integrated cloud properties product that we propose to generate on an operational basis from the continuous data streams from all the ARM sites. While the details of this product are beyond the scope of this document, our goal is to provide to the modeling group a product that describes where clouds occur in the atmosphere and our best estimate as to their properties. While some rendition of items 1-3 can be generated without reference to retrieval algorithms, items 4-7 rely on algorithms to convert the observations into microphysical and/or radiative properties. Items 5 and 7 also rely on interaction with elements of the IRF group to help define the radiative properties of the clouds and their influence on the radiative flux profile. With concerted effort, some rendition of this product is now within reach and, given a focused effort on the part of the CPWG and the ARM infrastructure, we are certain that a product like this could be a reality within the 1-year time frame. However, since we are more interested in articulating our vision of how the CPWG should function within the larger program, we will delay discussion of the details and use the integrated cloud product (ICP) outlined in Table 1 more as an example of our philosophy than a stated goal.

It is obvious that for something like the Integrated Cloud Product (ICP) to become a reality, a carefully orchestrated group/team approach to the problem must be adopted by the CPWG. In other words all active members of the group must agree to some sort of substantial contribution. Figure 1 outlines the organizational structure that might be adopted to make the ICP a reality. Each of the small rectangles within the larger CPWG box is a so-called theme group consisting of at least 1 individual science team member that has agreed to devote time and effort to generating a product. Ideally, the theme group would consist of several scientists, their graduate students and some form of ARM infrastructure support. An individual theme group member will be responsible for setting goals and timetables within the theme group. Their goal will be to develop a product characterizing their specific part of the ICP problem. For instance, the "Cloud Macroscale Properties" theme group would take the ARSCL product and any other pertinent information and provide a set of products to each of the cloud type-specific theme groups and to the Integration theme group. The specific details of these products would be determined by the needs of the theme group to which they are delivering information. Each of the cloud type-specific groups would be responsible for delivering to the Integration group some estimate of the cloud microphysical properties complete with error estimate for each time data are available. Each of the theme groups would be responsible for development, implementation and validation of their operational algorithms. Initially, we envision some rendition of climatology or simple regression-based cloud property estimates flowing into the ICP for certain cloud types such as mixed phase. Theme groups focusing on other cloud types such as cirrus could provide much more detailed information to the Integration group.

Figure 1. Cloud Properties Working Group Organizational Structure



Obviously, implementation of the ICP as an operational product will require substantial effort. The catchword that has been used in the past is a Value Added Product (VAP). Rather than viewing the ICP as a single VAP, it is more realistic to view each of the small boxes as generating a series (perhaps a half dozen) separate and specific VAPS that all eventually feed into the larger ICP (which we will refer to as a highly integrated product or HIP). The paradigm that has operated in the past required that official HIPs and their associated VAPs be initiated and run within the ARM infrastructure. While we view this as a productive and useful paradigm and one that should be retained, we also feel that the near-term implementation of development-level HIPs should be the responsibility of a working group and the VAPs the responsibility of the theme groups within the working group structure. In other words, while ARM infrastructure personnel are developing VAP code to run within the ARM infrastructure, the ARM program should support implementation of operational codes at the home institutions of theme group members. It seems evident that the science results should not be delayed by the availability of scarce resources when ample resources (manpower and enthusiasm) are available outside the infrastructure. The highest priority should be given to addressing the important science problems in the shortest possible timeframe. It would seem from our vantage point outside the ARM infrastructure that at least equal priority is now given to adhering to a rigid time consuming procedure to generate operational VAPS. This, combined with a shortage of human resources has led to a backlog of VAPS that will take at least 5-10 years to implement. Since the list of necessary VAPS are certain to grow substantially as highly integrated products are defined, we view the present situation as unacceptable and ultimately unhealthy for the ARM program.

In short, it seems evident from even a cursory scan of the recent proliferation of VAPs that sufficient human resources will never be available within the ARM infrastructure to implement them in a realistic timeframe. Delaying integrated products like the ICP until infrastructure resources can be directed at writing the code to run on DOE-owned computers will delay indefinitely the interdisciplinary interaction that is now needed to address the overarching science questions ARM has committed to answering.

3. Summary

It would appear that ARM has matured to the point where significant interaction between subdisciplines within the program is now not only possible but necessary. This is a certain sign of the maturity of the program and the success it has enjoyed in developing a data stream of unprecedented scope and quality. However, continued success is not guaranteed, and significant challenges face ARM in the coming years. Future success (defined as developing successful parameterizations for global models) rests on the ARM program transitioning from one of primarily building and maintaining a viable data stream to maintaining and interpreting that data stream. Constructing a research framework that will foster interpretation of the ARM data stream has been the subject of this document.

A certain amount of the interdisciplinary interaction that is now a required component of the ARM science program will proceed through ad hoc collaborations between individual scientists. While this is always a healthy endeavor, ARM cannot rely on this type of collaboration to fully address the overarching issues important to the program. In order to ultimately test, improve and develop new parameterizations for climate models, highly integrated products like the ICP (Table 1) are necessary. While the expertise exists within the science team to develop and implement this and similar products, it is essentially impossible for a single science team member or even a loose consortium of scientists to develop, implement and maintain something like the ICP. We reiterate that it seems likely that the future success of the ARM program rests on its ability to facilitate this type of activity. Furthermore, it is now evident that the current paradigm of requiring highly integrated products and the VAPS that compose them to be coded and run on DOE-owned computers at DOE labs will not lead to the near term scientific interactions that are necessary to advance the ARM program.

We provide the following recommendations:

- The STEC should become the primary venue for articulating the science goals of the project and outlining general and specific steps to meet these goals. This will certainly require the STEC to meet more often and for longer time periods in order to actually accomplish something.
- The working groups should be constructed around answering specific questions or developing specific highly integrated products (like the ICP) or sets of products.
- The working groups should be divided into theme groups that are responsible for very specific goals or tasks. These theme groups will be composed of a few scientists that have committed to developing and implementing a VAP or providing an answer to a question in some reasonable time frame.
- A new paradigm for fostering the interaction between subdisciplines within the ARM program must be defined. We suggest that ARM empower the working groups to develop, design, and implement operational highly integrated products in any way they see fit. Ultimately, the responsibility for implementing these products will transition to the ARM infrastructure but their initial implementation must not be delayed by this procedure.